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AUTHOR Ahmed, K.; Dickinson, C. J.
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ABSTRACT

MCAID is a relatively machine-independent technique for writing computer-aided instructional material consisting of descriptive text, multiple choice questions, and the ability to call compiled subroutines to perform extensive calculations. It was specially developed to incorporate test-authoring around complex mathematical models to explore a specific subject area, thus combining two broad categories of computer assisted instruction (CAI): programmed text and simulation programs. The text material and the associated branching information are contained on the text-file; computational routines reside in the compiled library. The MCAID driver, which monitors overall control, is programmed in FORTRAN and can be adapted to other programming languages. The driver, however, relies heavily on the ability to perform random access read/write on a card-image disc file, which contains all the test material and the branched logic. The driver has been successfully used at McMaster University to develop teaching and evaluation programs around complex physiological models. It has also been used to adapt CAI material developed elsewhere to a mini-computer. A simplified flow chart of the driver and examples of a typical test file and a typical student dialogue are appended. (Author/VT)

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MCAID - A Generalized Text Driver

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TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."

K. Ahmed, Ph.D.

McMaster University Medical School, Hamilton, Canada

C.J. Dickinson, D.M.

St. Bartholomew's Hospital Medical College, London, England

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MCAID

(McMaster Computer-aided Instructional Driver)

MCAID is a programming technique to derive a text-file with instructional frames and embedded branching logic and allows calls to compiled subroutines to perform extensive calculations. It has been specially developed to incorporate text-authoring around the physiological models MACMAN, MACPUF and MACPEE. However, the approach is quite general and machine-independent.

1. INTRODUCTION

The recent years have witnessed a great deal of activity in the area of computer-aided instructions (CAI)[1]. A variety of languages[2] and systems have evolved to provide authors with means for developing teaching and evaluation programmes. Existing programming languages have also been employed for this purpose. The existing CAI material can be classified into two broad categories viz., programmed text and computational (or simulation) programs. The first of these allow extensive text-handling and convenient control of branching logic but offer limited or no computational facility. The IBM Coursewriter[3] is a good example of this approach - it provides an excellent text-handling facility, however, it is difficult if not impossible to write a teaching program in such a language which will branch the student to a computational subroutine or a simulation program to perform complex computations. MUMPS[4] interpreter is another example of such a language which has many convenient text-handling features but limited precision and speed in arithmetic operations. The second approach, using commonly available programming languages such as FORTRAN, BASIC, PL/1 etc. allow an author to design complex mathematical models to explore a specific subject area. The Mac Family of Physiological models[5-8] MACMAN, MACPUF, MACPEE and MACDOPE are examples of this approach. However, these type of programs have limited text-handling since FORTRAN, BASIC, etc. are not primarily designed for text-handling and require large amount of computer memory for text formatting.

The two approaches, therefore, are contradictory, providing either text-handling facilities or computational capabilities but not both. In addition, they are generally machine-dependent and teaching material is seldom adaptable to different machines.

We have developed a driver program which combines both the objectives.

It is presently programmed in FORTRAN but can easily be adapted to other languages which allow direct-access read/write facilities on disc files. All the text material and its branching logic are stored on a card-image text-file. It can call compiled subroutines to perform special calculations and simulations. The overall branching is monitored by the MCAID driver (Fig. 1).

The need for such a system was recognized after we had developed the physiological models in FORTRAN. These models enabled a variety of experiments of human physiology but had very limited dialogue facility to explain or query the student about the simulations. The programs, therefore, did not always achieve full education potential. We feel that we have overcome this problem by the development of MCAID.

2. MCAID AND THE TEXT-FILE

The computational routines to be used in a CAI package are written in a programming language such as FORTRAN and compiled into a library accessible to the MCAID driver. The driver consists of several small routines (totalling about 600 FORTRAN statements). It drives the text-file and calls compiled subroutines when necessary (Fig. 1).

All the text material and the associated branching logic is contained in a card-image text-file which resides on disc. This file is organized into several frames, each of which contains several lines of text material and a unique branching logic, characterized by the frame-type. There are 10 types of frames which will be described in some detail in the next section. The three most important frame types are the Q-frame(question-frame with conditional branch based upon the response); the T-frame (text-frame with unconditional branch) and the S-frame (sub-routine-frame, calls a specified subroutine).

Normally the driver starts execution at a specified frame (the Begin-frame) and branches forward or backward to any frame in the text-file depending upon the user response and the branching logic of the current frame. When an S-frame is encountered, the driver determines the subroutine number to be called. It then calls a specific subroutine MCSUB which then relates this number to the appropriate subroutine from a list of library routines and calls the subroutine. Upon return, the driver determines the next frame number to be executed (out of one or more possible candidates) and transfers control to that frame. MCSUB, therefore, acts as a window through which the driver communicates with the compiled subroutines for a particular teaching program. These subroutines can be used for any conceivable purpose such as mathematical calculations, randomization, special string-handling, plotting graphs, etc. etc. It is this feature that enhances the power of MCAID.

3. FRAME-TYPES

The MCAID text material is stored on a text-file consisting of an arbitrary number of frames. Each frame has a unique number and branching logic and may contain several lines of text. A typical Q-frame is illustrated in Figure 2. The execution of this frame proceeds as follows. After displaying the text lines from this frame, the driver accepts input from the terminal. If the answer is "YES" a branch to frame number 200 will be made, if the answer is "NO" a branch to frame 80 will be made. It is also possible to allow for numeric response or null response (i.e. match any answer).

There are 10 frame-types in MCAID. Briefly, their functions are:

T-FRAME Contains descriptive text and an unconditional branch to another frame in the text file.

Q-FRAME — Contains multiple-choice questions and a list of possible frames to branch to.

S-FRAME — Contains text and a subroutine No. to be called. The driver locates this subroutine and activates it; upon return the driver passes control to a specified frame.

D-FRAME — A dummy frame which does not have its own branching logic but contains text lines which can be used by other frames.

B-FRAME — Specifies the starting frame in the lesson.

E-FRAME — Specifies the end frame - terminates the program.

G-FRAME — Specifies global keywords (such as 'STOP', 'HELP') checked against all responses, and corresponding frames to branch to.

F-FRAME — Set flag to a specified value.

I-FRAME — Branch to a frame if the flag has a specified value.

4. CONCLUSIONS

We have developed a relatively machine-independent technique for writing computer-aided instructional material consisting of descriptive text, multiple-choice questions and the ability to call compiled subroutines to perform complex computations. The MCAID driver is programmed in FORTRAN (about 600 statements) and can be adapted to other programming languages. The driver however, relies heavily on the ability to perform random access read/write on a card-image disc file, which contains all the text material and the branching logic.

A simplified flowchart of the driver appears in Appendix A. An example of a typical text-file is shown in Appendix B. Example

of a typical student dialogue appears in Appendix C.

The driver has been successfully used at McMaster University to develop teaching and evaluation programs around complex physiological models. It has also been used to adapt CAI material developed elsewhere to a mini-computer, which would have been impossible otherwise.

We feel that the MCAID approach offers a convenient means of combining text-material with extensive computations on most computers. The author can prepare his text material on special forms which are easily coded and transferred to a disc file (e.g. by means of keypunched cards or a text-editor).

FORTRAN source listing of the driver, example of text-file and author forms are available from the first author. A technical manual is in preparation.

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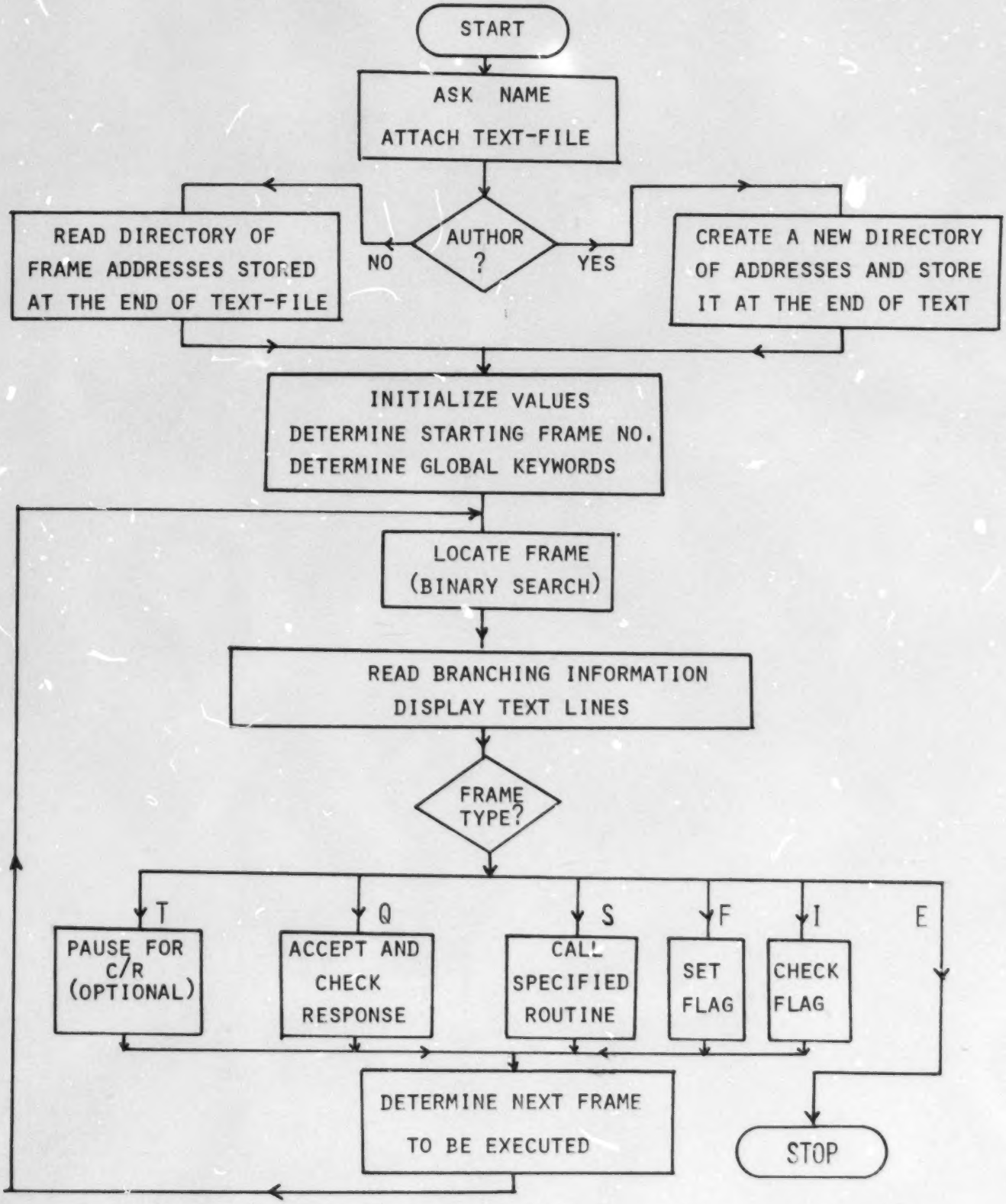
APPENDIX A

FLOW OF CONTROL OF THE MCAID DRIVER



APPENDIX B

EXAMPLE OF A TEXT-FILE

```
1     *R    1  555
2     *G "STOP",900 "OPTIONS",9
3     *C-------------------------------------------------------------------*
4     *C                                                                   *
5     *C            MCNNTEXT  (MCAID TEXT FOR MACMAN PROBLEMS)             *
6     *C                                                                   *
7     *C AUTHORS: DR.K.AHMED, DR.C.J.DICKINSON & DR.G.D.SWEENEY            *
8     *C          COMPUTATION SERVICES UNIT,                               *
9     *C          MCMASTER UNIVERSITY MEDICAL SCHOOL, HAMILTON, ONT., CANADA *
10    *C          AUGUST 1976                                              *
11    *C-------------------------------------------------------------------*
12    *0  1 0  'Y',9  'N',2
13       THIS PROGRAM INTRODUCES YOU TO THE PHYSIOLOGICAL MODEL 'MACMAN' BY
14     MEANS OF SOME SIMPLE EXAMPLES AND ALLOWS YOU TO PERFORM YOUR OWN
15     SIMULATION EXPERIMENTS.
16     HAVE YOU USED THIS PROGRAM BEFORE? (ANSWER Y OR N AND PRESS 'RETURN')
17    *T  2 0 0 1000
18     THIS MATERIAL WAS DEVELOPED BY DRS.K.AHMED, C.J.DICKINSON & G.D.SWEENEY
19     AT MCMASTER UNIVERSITY. IT HAS THREE GOALS:-
20     (1) TO INTRODUCE YOU TO A COMPUTER SIMULATION OF RAPID CARDIOVASCULAR
21         RESPONSES IN MAN,
22     (2) TO TEACH YOU THE BASIC PRINCIPLES OF SYSTEMIC HEMODYNAMICS,
23     (3) TO ALLOW YOU TO TEST YOUR UNDERSTANDING OF THE CIRCULATION OF
24         MAN, AND YOUR SKILL IN ANALYSING DIFFICULT PROBLEMS.
25    *T  4 0 0 5
26     I SHALL TAKE YOU INTO THE MODEL AND OFFER YOU A NORMAL(INTACT) SUBJECT.
27     YOU CAN THEN CHANGE ANY OF THE FIVE FACTORS (E.G. BLOOD VOLUME) AND
28     SEE THE EFFECTS.
29        WHEN YOU ARE ASKED THE QUESTION 'DO YOU WANT TO 1.CHANGE, 2.CONT..',
30     FIRST ASK FOR '1.CHANGE ' & PRESS RETURN, THEN '1.CHANGE VALUES' (PRESS
31     RET), THEN ENTER '5' (FOR BLOOD VOL.), PRESS RET, THEN PUT IN THE NEW
32     VALUE FOR FACTOR 5 (BLOOD VOL IN MLS.). FINALLY, ASK FOR '2.CONTINUE'.
33     ......IT WILL LOOK A LOT SIMPLER ONCE YOU HAVE DONE IT!  WHEN YOU ARE
34     READY TO COME BACK TO TALK TO ME SPECIFY 'STOP THE MODEL'.
35    *S  5 0 5  6
36    *C << CALL MACMAN, OFFER NORMAL SUBJECT AND ALLOW INTERACTION >>
37    *0  6 0 (1)8 (2)900
38     I HOPE YOU HAVE GOT A GOOD IDEA OF WHAT THE MODEL CAN DO FOR YOU.
39     IF YOU HAVE ANY PROBLEMS IN THE DISCUSSION SO FAR, PLEASE FIND A
40     RESOURCE PERSON WHO CAN HELP, OR CONSULT THE 'MACMAN HANDBOOK' WHICH
41     CONTAINS A FAIRLY DETAILED ACCOUNT OF THE MODEL AND HOW TO USE IT.
42     SHALL WE  1.PROCEED FURTHER, OR  2.STOP AT THIS POINT?
43    *0  8 0 'Y',10 'N',9
44     IF YOU WISH YOU CAN GO BACK TO THE MODEL AND TRY DIFFERENT VALUES OF
45     BLOOD VOLUME AND GRAPH THE BLOOD PRESSURE AND HEART RATE, OR FOR THAT
46     MATTER DO ANY OTHER EXPERIMENTS. WOULD YOU LIKE TO DO THAT?
47    *C---------------------- CENTRAL CONTROL POINT ----------------------
48    *0  9 0 (1)10 (2)20 (3)400 (4)320 (5)900
49     SINCE YOU ARE FAMILIAR WITH THE USE OF THE MODEL PATIENT 'MACMAN',
50     I CAN OFFER YOU FIVE CHOICES:
51       1.JUST TO CALL UP THE MODEL AND PERFORM ANY EXPERIMENTS YOU LIKE,
52       2.TO EXPLORE THE ROLE OF NERVOUS REFLEXES IN PROTECTING THE
53         CIRCULATION FROM THE ILL EFFECTS OF MODERATE HAEMHORRHAGE,
54       3.TO TEST YOUR UNDERSTANDING OF THE SYSTEMIC CIRCULATION BY A
55         SEARCHING EVALUATION EXCERCISE IN PROBLEM SOLVING,
```

```
513      1..ART. RESISTANCE=  100.0 PC OF NORMAL
514      2..VEN. RESISTANCE=  100.0 PC OF NORMAL
515      3..CARDIAC CONTRACTILITY=  100.0 PC OF NORMAL
516      4..MEAN INTRATHORACIC PRES.=  -2.0 MM HG
517      5..BLOOD VOLUME=  5000.0 ML
518
519      IF YOU DON'T UNDERSTAND WHAT THESE FACTORS MEAN OR WHAT THEY CONTROL
520     *Q 1030 0 'GO',1090 '1',1040 '2',1050 '3',1060 '4',1070 '5',1080
521      TYPE THE FACTOR NUMBER.  WHEN YOU WANT TO PROCEED FURTHER TYPE 'GO'.
522     *T 1040 0 1 1030
523      ARTERIAL RESISTANCE IS A MEASURE OF THE PRESSURE REQUIRED TO DRIVE
524      BLOOD THROUGH THE SYSTEMIC CIRCULATION AT A DESIRED RATE.BLOOD PRESSURE
525      CAN BE VIEWED AS THE PRODUCT OF CARDIAC OUTPUT AND ARTERIAL RESISTANCE;
526      IF ARTERIAL RESISTANCE IS INCREASED MUCH ABOVE NORMAL, HYPERTENSION
527      RESULTS;  IF IT IS MUCH BELOW NORMAL,  SHOCK MAY ENSUE.
528     *T 1050 0 1 1030
529      ONLY A SMALL PRESSURE IS NEEDED (OR AVAILABLE) TO PUSH BLOOD THROUGH
530      THE VEINS BACK TO THE HEART, BUT VENOUS RESISTANCE IS NEVERTHELESS
531      IMPORTANT IN DETERMINING RETURN OF BLOOD TO THE HEART.  AN INFERIOR
532      VENA CAVA OBSTRUCTION MAY WELL INCREASE VENOUS RESISTANCE
533      DRAMATICALLY.
534     *T 1060 0 1 1030
535      "CONTRACTILITY" DESCRIBES THE EFFECTIVENESS OF THE HEART'S MUSCULAR
536      ACTION - OBVIOUSLY IT IS DECREASED IN INFARCTION.
537     *T 1070 0 1 1030
538      DUE TO VARIOUS FACTORS RELATING TO THE MECHANICS OF BREATHING, THE
539      AVERAGE PRESSURE WITHIN THE CHEST IS NEGATIVE AND THIS HELPS GET BLOOD
540      BACK TO THE HEART. IF YOU PUT A PATIENT ON A RESPIRATOR THIS NO LONGER
541      APPLIES.
542     *T 1080 0 1 1030
543      IF YOU DON'T KNOW WHAT BLOOD VOLUME IS YOU SHOULD NOT BE IN MEDICAL
544      SCHOOL!
545     *Q 1090 0  'Y',4   'N',9
546      O.K. - SO YOU KNOW THAT 'MACMAN' ALLOWS YOU TO DO EXPERIMENTS ON A
547      SIMULATED HUMAN. IT PRINTS OUT BLOOD PRESSURE AND PULSE RATE READINGS
548      EVERY TWO SECONDS AS THE CARDIOVASCULAR SYSTEM ADAPTS RAPIDLY TO
549      CHANGES IN IMPORTANT THINGS SUCH AS THE AMOUNT OF BLOOD.
550      IN ADDITION EXACT FIGURES WILL BE GIVEN TO YOU FOR THESE FACTORS.
551      HOWEVER, WHEN YOU CHANGE THE FACTORS NO PRIOR KNOWLEDGE OF NUMBERS
552      IS REQUIRED.
553      DO YOU WANT TO DO AN EXPERIMENT? (ANSWER YES OR NO)
554     ************************************************************************
555      111
556      900   2   1  12   2  17   4  25   5  35   6  37   8  43   9  48  10  60
557       20  65  30  74  40  76  50  82  60  84  70  90  80  98  90 102 100 105
558      110 113 120 115 122 124 124 126 126 128 128 130 130 132 140 136 150 138
559      156 147 160 154 170 158 172 160 180 162 190 173 200 177 210 180 220 187
          :
566      700 420 710 422 730 426 740 439 750 442 760 444 770 449 800 457 810 459
567      830 463 900 4691000 4721010 4931020 5061030 5201040 5221050 5281060 534
568     1070 5371080 5421090 545
569     SSSSSQQDQDTQSQQTTQTTTQTTQTTED
```

(Note: The directory of frame addresses is stored in the text-file after the last frame. A simple binary search on this table is done to locate a particular frame).

APPENDIX C

A TYPICAL EXAMPLE OF STUDENT DIALOGUE WITH MCAID (using MacMan)

```
   THIS PROGRAM INTRODUCES YOU TO THE PHYSIOLOGICAL MODEL 'MACMAN' BY
MEANS OF SOME SIMPLE EXAMPLES AND ALLOWS YOU TO PERFORM YOUR OWN
SIMULATION EXPERIMENTS.
HAVE YOU USED THIS PROGRAM BEFORE? (ANSWER Y OR N AND PRESS 'RETURN')
? NO

THIS MATERIAL WAS DEVELOPED BY DRS.K.AHMED, C.J.DICKINSON & G.D.SWEENEY
AT MCMASTER UNIVERSITY. IT HAS THREE GOALS:-
(1) TO INTRODUCE YOU TO A COMPUTER SIMULATION OF RAPID CARDIOVASCULAR
    RESPONSES IN MAN.
(2) TO TEACH YOU THE BASIC PRINCIPLES OF SYSTEMIC HEMODYNAMICS.
(3) TO ALLOW YOU TO TEST YOUR UNDERSTANDING OF THE CIRCULATION OF
    MAN, AND YOUR SKILL IN ANALYSING DIFFICULT PROBLEMS.
<PRESS RETURN>
?

I ASSUME YOU HAVE NOT USED 'MACMAN' BEFORE.  THIS IS A MODEL OF THE
HEART AND SYSTEMIC CIRCULATION DESIGNED TO ILLUSTRATE RAPID HOMEO-
STATIC RESPONSES.  LET US TAKE A NEW PATIENT. HERE IS A PRINT-OUT OF
BLOOD PRESSURE (XXXX) AND PULSE RATE (....) OF A NORMAL SUBJECT FOR
THE PAST 30 SECONDS.  NOTE THAT THE TIME AXIS IS VERTICALLY DOWNWARD.

TIME 0  20  40  60  80  100 120 140 160 180 200 220 240 260 280 300
SECS .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
 -28                .XXXXXXXXX
 -24                .XXXXXXXXX
 -20                .XXXXXXXXXX
 -16                .XXXXXXXXXX
 -12                .XXXXXXXXX
  -8               .XXXXXXXXXX
  -4                .XXXXXXXXXX
   0                .XXXXXXXXXX

IF IN YOUR MIND YOU TURN THE GRAPH 90 DEGREES ANTICLOCKWISE, IT
BECOMES A STANDARD B.P. AND PULSE CHART, WITH TIME (IN
SECONDS) ALONG THE BOTTOM.
<PRESS RETURN>
?

OBVIOUSLY NOT MUCH IS GOING ON AT PRESENT:  PULSE AND BLOOD PRESSURE
ARE STABLE. HOWEVER,THIS RESULTS FROM THE INTERACTION OF MANY DIFFERENT
FACTORS AND THE SECOND PART OF A 'MACMAN' PRINT-OUT IS A LIST OF
PHYSIOLOGIC VALUES OPERATING WHEN THE LAST READING FOR BLOOD PRESSURE
APPEARED HERE IN THE PRINT-OUT: DON'T BOTHER WITH THE FIGURES AT THE
MOMENT: OUR OBJECTIVE IS TO HELP YOU LEARN WHAT THESE MEAN.

B.P. SYSTOLIC=121  DIASTOLIC= 76  MEAN=  91.3
RIGHT ATRIAL PRESS.= 1.7 MM HG  MEAN CAPILL.PRESS.=    12.7 MM HG
CARDIAC OUTPUT=  5.0 L/MIN, STROKE VOL.=  68.0 ML, HEART RATE=  73.
ART.RESIST.=  16.0   VENOUS RESIST.=  2.2 MM HG/L/MIN
CARDIAC CONTRACILITY=  1.3 L/MIN/MM HG FILLING PRESS.
<PRESS RETURN>
?

'MACMAN' IS A RESILIENT FELLOW AND WELCOMES EXPERIMENTS HOWEVER
UNETHICAL. YOUR EXPERIMENTS MAY KILL HIM BUT REINCARNATION IS
IMMEDIATE! THE FACTORS YOU CAN ALTER IN DOING EXPERIMENTS ARE LISTED
BELOW: THE VALUES SHOWN ARE THOSE AT THE END OF THE RUN GRAPHED OUT
ABOVE.

1..ART. RESISTANCE=  100.0 PC OF NORMAL
2..VEN. RESISTANCE=  100.0 PC OF NORMAL
3..CARDIAC CONTRACTILITY=  100.0 PC OF NORMAL
4..MEAN INTRATHORACIC PRES.=  -2.0 MM HG
5..BLOOD VOLUME=  5000.0 ML

IF YOU DON'T UNDERSTAND WHAT THESE FACTORS MEAN OR WHAT THEY CONTROL
TYPE THE FACTOR NUMBER.  WHEN YOU WANT TO PROCEED FURTHER TYPE '60'.
?
```

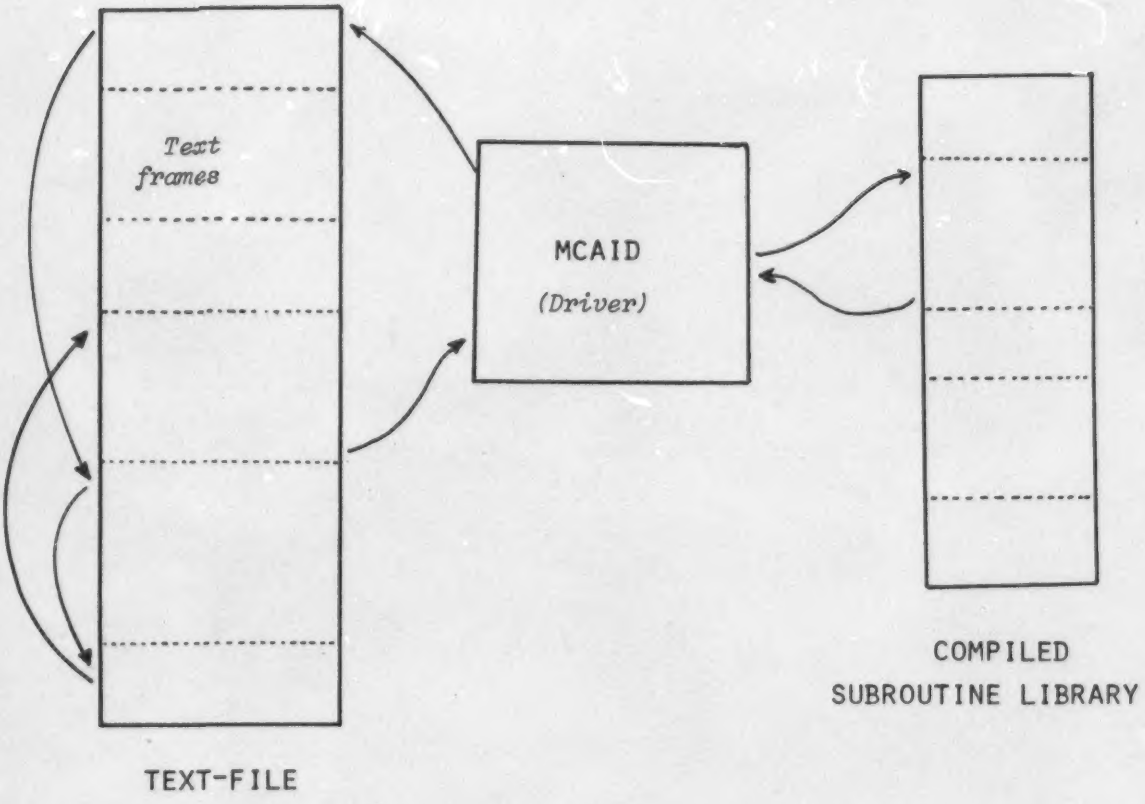


Fig.1 - COMPONENTS OF MCAID. The text material and the associated branching information is contained on the text-file. Computational routines reside in the compiled library. MCAID driver monitors over-all control.

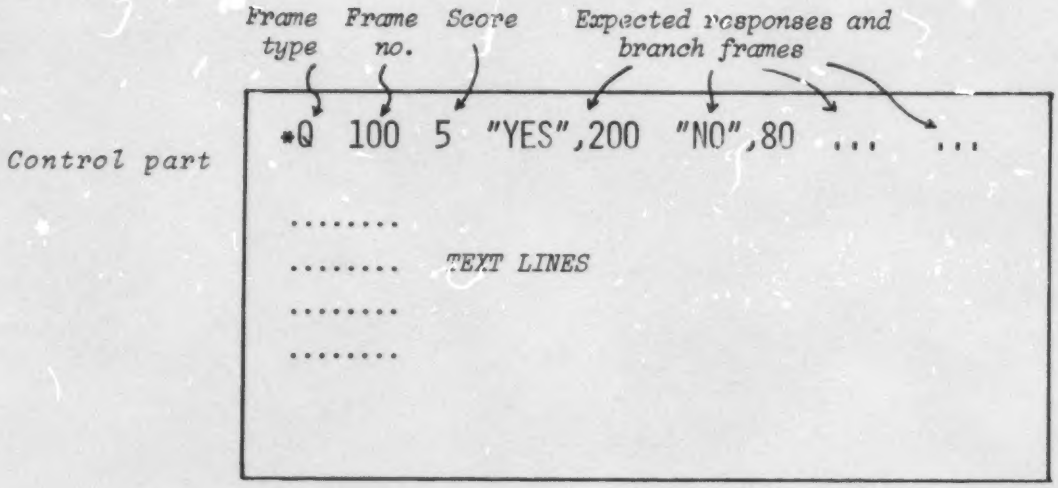


Fig. 2 EXAMPLE OF A TYPICAL Q FRAME